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Research Article

Occupational Health and Safety Management in Risk Control in Underground Diamond Drilling Activity CMH Mining Company – Parcoy Mining Unit

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ABSTRACT

Underground diamond drilling is one of the activities that has generated a number of dangerous incidents, accidents and even fatalities, for which analysis and risk assessments carried out in diamond drilling work are required to which each of the workers who carry out this diamond drilling activity. The present investigation whose objective is to determine the influence of occupational safety and health management in drilling activity Diamond drilling at the Parcoy Mining Unit was developed in the context of the insecurity that workers are exposed to in this diamond drilling activity. The problem of the investigation arises due to the extent to which Occupational Health and Safety Management is important to control the risks in the diamond drilling activity in underground mining, for the development of the problem it was used in a type of correlational investigation of observational design, the sample used were the collaborators who carry out the underground diamond drilling activity in the Parcoy Unit - CMH.

Keywords: Underground mining, diamond drilling, risks, occupational health and safety management.

INTRODUCTION

In all underground mining exploration activity, a sequence is applied for the development of diamond exploration: (galleries, fronts, ramps, crossings). Of the stages described above and based on the national accident statistics of the Ministry of Energy and Mines (MINEM) from 2011 - 2020, the drilling stage is the one that has generated and generates the highest number of dangerous incidents, serious accidents and even fatal accidents.

López (2022) indicates "Substandard acts and conditions are signs that basic or underlying problems exist within the system to prevent losses as a medicine, treatment symptoms often distract attention from identifying and correcting the basic causes" (López, 2022, p. 7)

Sumimoto (2021) also specifies in this regard that "The activities of this stage include the following tasks: diamond drilling, procurement, coding, transport, study of drilling cores (logging), sampling and storage of cores" (Sumimoto, 2021, p. 8)

The purpose of this research is how the GSSO is developed in the underground diamond drilling activity, in order to improve and achieve sustainability of the GSSO Policy, objectives, and goals. And the way in which the PHVA (plan, do, verify, act) is used, being the methodology applied in the work area, and in the occupational health and safety management system.

Since the purpose of every company is to control expenses, dose energy, and services used for survival and competition. The research developed will contribute to prevention, productivity, and

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competition, for which the GSSO will be the effective tool for continuous improvement in the GSSO of our collaborators (Alonso & Lovera, 2022, p. 240), in this case who carry out face-drilling work with the various hydraulic machines.

Effective management is based on prevention and accidents, reducing costs and increasing productivity in diamond drilling operations, which is why safety management is effective for the improvement of occupational health and safety in order to avoid injuries, illnesses to workers in the diamond activity.

It is about solving the problem of ***To what extent is Occupational Health and Safety Management important to control risks in the diamond drilling activity in underground mining?***

The research is justified by the need to control and minimize the risks to Occupational Health and Safety in underground diamond drilling workers, who are exposed to various hazards called agents; (physical, chemical, biological, disergonomic, mechanical, and/or locative). Which, by not identifying and evaluating them, have a negative impact on the safety and health of the workers, and the mining company.

In this sense, what the research seeks is to contribute to a study that will identify, evaluate, establish and document guidelines that contribute to Occupational Health and Safety Management to improve the results of underground diamond drilling activity, thus strengthening through positive aspects and implementing action plans if necessary. to improve the level of satisfaction in the GSSO.

Mining is one of the oldest and most important activities of man, this arises through the process of collecting various types of rock to finally use them in tools. In addition, the vast majority of the materials used by modern society are obtained by mining, which is why the mining industry is of great importance to humanity. Its classification of mining is to surface mines and also underground mines, however, at the labor level mining is a high-risk activity, but also of high profitability, many times the extraction of mining wealth has led to safety risks in workers and physical goods. This is in addition to the lack of supervision, and the mistakes of the collaborators when violating some rules established by the mining companies.

On the other hand, from the (Ministry of Energy and Mines, 20167) D.S. No. 024: Art. 7, establishes the GSSO: Application of the principles of modern management to safety and health, integrating it into production, quality and cost control" based on ISO 45001:2018, Occupational Health and Safety Management Systems — Requirements with Guidance for Their Use) with the aim of preventing injuries, and deterioration of health according to the working conditions and also depending on the type of industry where they are able to perform. The occupational health and safety system at work will be as efficient when immediate prevention measures are taken. The implementation of the OSH system will depend on the improvement and performance of occupational health and safety and the implementation of management through compliance with legal and organizational requirements.

And considering this, Risk Control is worked on from the ISO 45001: 20018 Standard, it is an international system that is based on the management of minimizing accidents and occupational diseases, which consists of the development of the logical process, based on continuous improvement, where it includes policy, organization, planning. The application, auditing and improvement actions in the work that you develop as a company, considering that the planning, implementation and control of processes necessary to be able to control risks is required, since the approach will depend on the control in the process activities, the applicable method would be to replace the risk, isolate the risk, the engineering controls, administrative controls, and the employability of personal protective equipment.

For the following reasons, the records of incidents and accidents or diseases must also be reviewed in order to make action plans and to be able to make the use of risk controls for the prevention

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of incidents and accidents in the work area. It is feasible to prioritize the risks identified and how high they can generate their negative impact on the company.

Regarding the Typology of underground diamond drilling work, it involves facts that are typical of the handling of fluids for it, being diamond **drilling,** one of the most used drilling methods par excellence of activity (Mao et al, 2020. p. 3), due to the information it is capable of providing geological engineers with the study and cubing of mineral deposits, being valuable information for the drilling system. exploitation to be applied, with diamond drilling equipment of the following labels:

DATOS TECNICOS DE LA LM30SS DRILLCAT	
La minicargadora LM 30SS es una barrena sacatestigos diamantada móvila para perforación subterránea, adecuada a perforar secciones de 2.5 X 2.5m	
UNIDAD MOVIL	La unidad comapcta y móvil asegura una rápida instalación y factibilidad de movimiento de un sitio a otro
CONTROLES VARIABLES	Los controles variables aseguran un funcionamiento uniforme durante toda la operación.
BASTIDOE DE AVANCE CON APILAMIENTO DIRECTO:	El bastidor de avanxce con acoplamiento directo reduce los requerimientos de mantenimiento
DESCONEXION POR ALTA PRESIÓN	El sistema de desconexión cuenta con un circuito de alta presión para desenganchar las juntas de las varillas sin esfuerzo
POSICIONADOR Y PLATAFORMA GIRATORIA INTEGRADOS	El posicionador y la plataforma giratoria integrados permiten perforar en un ángulo de 360 grados y en dirección ascendente y descente con facilidad
ABRAZADERA DE VARILLAS A PRUEBA DE FALLAS	La abrazadera de varilla de cierre por resorte y de apertura hidráulica garantizada una operación a prueba de fallas en caso de explosión de una manguera
SISTEMA HIDRAULICO INTELIGENTE	El sistema hidráulico inteligente, con control sincronizado entre la unidad de giro y la abrazadera de ´pie, permite una manipulación de las varillas más rápida y segura.

Figure 1: Drill Cat Skid Steer Loader Data:

Source: LM 3055 Drillcat Technical Catalog. In original Spanish language

This type of machine is used for 2.5 x 2.5m section work

DATOS TECNICOS SUPERDRILL H 400 -2	
H 400 -2 es una perforadora diamantina de dimensiones que permite su instalación en cámaras de hasta 6 X 6 X 8m de altura con una capacidad de perforación capaz de cubrir taladros de profundidades que demanda su estudio de exploración minera, gracias a su diseño modular facilita su traslado, la SUPERDRILL H 400/ D permite perforar desde HQ hasta AQ con sistema wireline en todos los ángulos (-90° -+90°)	
UNIDAD MOVIL - H 400	La unidad comapcta y móvil asegura una rápida instalación y factibilidad de movimiento de un sitio a otro
CONTROLES VARIABLES	Los controles variables aseguran un funcionamiento uniforme durante toda la operación.
BASTIDOE DE AVANCE CON APILAMIENTO DIRECTO:	El bastidor de avance con acoplamiento directo reduce los requerimientos de mantenimiento
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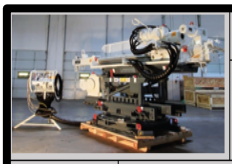
Figure 2: Maqpower H400-2 Machine

Source: Technical Catalogue H 400 – 2. In original Spanish language

This type of machine is used for 6 x 6m section work.



DATOS TECNICOS DE LA LM 75	
La minicargadora LM 75 es un equipo para perforación diamantina de tamaño mediano para perforación subterránea para perforaciones profundas y las dimensiones para la perforación en unos 360° la cabina de perforación es 6 X 6m .	
UNIDAD MOVIL	La unidad compacta y móvil asegura una rápida instalación y factibilidad de movimiento de un sitio a otro
CONTROLES ESTÁNDAR	Los controles comunes con otras equipos de la serie de perforación subterránea facilitan la capacitación cruzada de los perforadores
SISTEMA HIDRAULICO CON SENSOR DE CARGA	El sistema hidráulico con sensor de carga aumenta al máximo la eficiencia y reduce el calor.
CONTROLES PROPORCIONALES	Los controles proporcionales y las palancas de traba ofrecen un control óptimo de las rpm y el avance.
DESCONEXIÓN DE PAR TORSOR ELEVADO	Un dispositivo automatizado de desconexión de par tosor elevado desconecta la mayoría de las juntas de varillas en forma automática.

Figure 3: LM75 Boart Longyear machine

Source: LM 75 Technical Catalogue. In original Spanish language

This type of machine is used for 6 x 6m section work

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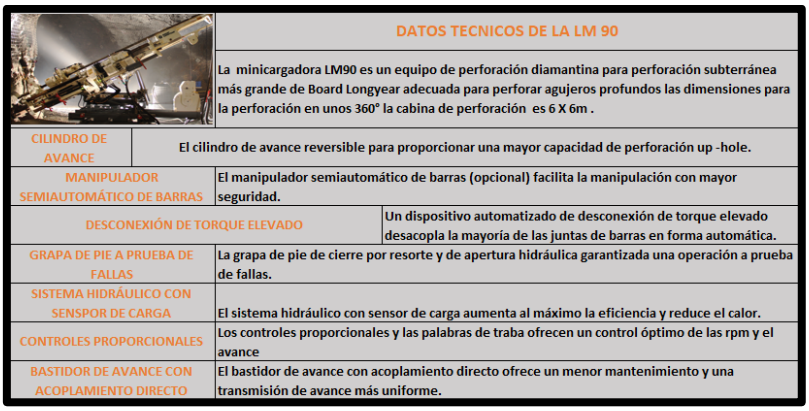

Figure 4: LM90 Boart Longyear machine

Source: LM 90 Boart Longyear Technical Catalogue

This type of machine is used for 6 x 6m section work

METHODOLOGY.

The research is applied based on the explanatory method, for the analysis of data in order to realize a scope according to the design based on observations in the operation of the underground diamond drilling activity. (Mao et. al., 2020, p. 2)

It is a non-experimental study with an explanatory and comparative scope, based on observation of underground diamond drilling activities in order to interpret the information from the occupational health and safety management system, with respect to risk control.

Relating the independent variable (occupational health and safety management) with the dependent variable (risk control in the diamond drilling activity in underground mining CMH Mining Company – Parcoy Unit, since verifying the management guarantees the adequate control of the continuous improvement of the Deming and Steward cycle, establishing the applicable obligations of the company allowing a better control of risks in the diamond operation,

The population and sample are: 34 workers who carry out the underground diamond drilling activity with the DRILLCAT -LM75 - LM90- H400 2 machines in the Parcoy Mining Unit – Consorcio Minero Horizonte S.A. By deciding what is the entire sample

Table 1: Distribution of Personnel

Personal	Day shift	Night shift	Total Personnel
DDH Master Driller	6	6	12
DDH Assistant	11	11	22

Source: Company Personnel Register

The data collection techniques and instruments will be supported by observation, reports, statistical data, survey and interview, provided by SSO of the Parcoy Mining Unit – Compañía Minero Horizonte S.A. And the questionnaire that is carried out will allow it to be used as an instrument for research and evaluation of people in the process and their training program. This evaluation technique can cover quantitative aspects, as well as qualitative aspects.

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RESULTS

Description of the risk.

The types identified, the levels of risks according to the diamond drilling activity in faces will be obtained from the collection of data, supported by observation, reports, documents, statistical data, survey, as well as procedure manuals and legal standards applied to the activity of the mining sector. It should be noted that the following activities were evaluated and compared:

- Diamond drilling in sections of 2.5 x 2.5m using Drillcat machine.
- Diamond drilling in sections of 6 x 6m using H 200 -4 machine. LM 75, LM 90.

a) Information on the machines used in underground diamond drilling:

The first step of the investigation corresponded to the collection and review of the manufacturer's manuals of the DRILLCAT (Board Longear) Underground Diamond Drilling Machines, H400 -2 Machine (MAQPOWER), LM75 Machine (Board Longear), LM90 Machine (Board Longear).

We allowed us to take the dimensions of the machines and equipped (length, weight) required energy, need for water consumption, noise generation, vibration.

b) Collection of statistical information on occupational accidents and diseases:

Statistical data based on occupational accidents and diseases in the period from 2020 to 2022 and occupational diseases were collected, organized, and analyzed.

This allows us to have solid information on the impact of the accident rate of the subject of our research, related to the job position of master drillers and diamond drilling assistants.

c) Identification of activities and tasks in underground diamond drilling activity

We based ourselves on the observations of the use and employment of diamond drilling machines, managing to identify the activities, tasks and a record used in typical work shifts.

- Drilling in section of 2.5 x 2.5m Drillcat machine.
- Drilling in sections of 6 x 6mm machine H 400 2, LM75, LM90.

d) Identification of hazards and their related risks in underground drilling

Based on the referential list of hazards applied to processes, activities and tasks.

- Hazards, Physical and Chemical Hazards
- Biological Hazards,
- ergonomic hazards,
- Mechanical accident hazards,
- Potential emergency situation,
- Locative hazards and
- Mechanical hazards.

Table 2: Reference list of hazards

Physicists		Chemists	
1	Noise	7	Dust (exposure to)
2	Vibrations	8	Fogs/haze (exposure in)

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3	High Extreme Temperatures	9	Humidity (exposure in)
4	Non-ionizing radiation	10	Gases (inhalation generated by)
5	Ionizing radiation	11	Vapors (contact with vapors)
6	Lighting	12	Liquids (HNO3, H2O2, oils)
Biological			
13	Bacteria, fungi, viruses, parasites, protozoa	14	Rodents, mosquitoes
Disergonomic		Mechanical or accident	
15	Physical overexertion	24	Proper physical organization
16	Manual lifting and carrying of weight (top, bottom=	25	Lack of order and cleanliness
17	Forced work postures and repetitive motion	26	Mobile equipment or machinery
18	Night work	27	Rotating or moving parts
19	Poor ventilation	28	Inadequate or defective tools
20	Long working hours	29	Loose rocks
21	Monotony and repetitiveness	30	Objects or materials at height
22	Isolation	31	Electrical equipment and installations
23	Other situations that cause stress	32	Explosive materials
Potential emergency situations			
33	Working at height	41	Hydraulic, pneumatic equipment and installations
34	Vehicular transport	42	Obstacles on the floor, fall and personnel
35	Fire	43	Confined spaces
36	Earthquakes	44	Hot work
37	Thunderstorms	45	Uneven surface
38	Huayco	46	Uneven surface
39	Rains	47	Roads, lanes in poor condition
40	Social unrest	48	Defective equipment or machinery

Source: Own master's degree student

For the analysis, the methodology of the 5 Ws + T has been used, this refers to the 5 Ws is a methodology developed by Lasswell (1985) that consists of answering the 5Ws, whose expressions in English are: What?, When?, Who?, Why?, Where?: What?, Where?, Who?, Why? and Where?.

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Potential Emergency Situations

The mining authorities establish them as an unexpected event generated by a natural phenomenon or human action that can cause catastrophe with loss of human routes and material damage.

The result of the 5W+T application allows us to understand the exposed hazards of diamond drilling personnel in underground mining, and the risks are related to the aspects of diamond operation development.

The development of the IPERC matrix at the beginning of drilling activities is very important and in order to assess the initial risk in diamond drilling in (galleries, faces, ramps, bypass).

The IPERC matrix analyzed:

- Physical hazards of all kinds, also generated by different equipment and that pose permanent or temporary risks depending on the circumstances, from noise, high temperatures, lighting, detachments and irregularity in the floors.
- Mechanical hazards that can be caused by machinery or parts that rotate in and out of the mine at various times, including drilling.
- Disergonomic hazards related to overexertion, forced postures and repetitive motion.
- Locative hazards, such as the organization of physical space, order and cleanliness, tools, heavy suspended objects, obstacles on the floor and roads in poor condition.
- Chemical hazards, presence of dusts due to activity, phases of O2, CO and CO2, in addition to the oils that are emitted.
- Biological hazards, which refer to present dusts and O2 gases,

Risk assessment according to D.S. 024 – 2016EM

The risk assessment, according to the current national standard of the mining subsector, applying the Hazard Identification, Risk Assessment and Control Measures - Baseline (IPERC LB), evaluates the criteria applied for: occupational safety (injuries), occupational hygiene (occupational diseases). Also determined by Annex 07 of D.S. No. 024 – 2016 EM, for the analysis of Severity, in addition to the probability table, the risk assessment has also been carried out considering the established levels.

Table 3: Risk in diamond drilling activities

	1.1. On-call dispatch	1.2. Transfer to work	1.3. Initial verification of work	1.4. Machine Conditioning	1.5. DDH Drilling	1.6. Dining room	1.7. Drilling Completion	1.8. Drill Report
Low	0	6	12	18	21	5	8	0
Middle	5	5	10	16	30	5	8	2
High	0	1	1	2	4	0	2	0

Source: Company Registry, systematized by the master's degree student

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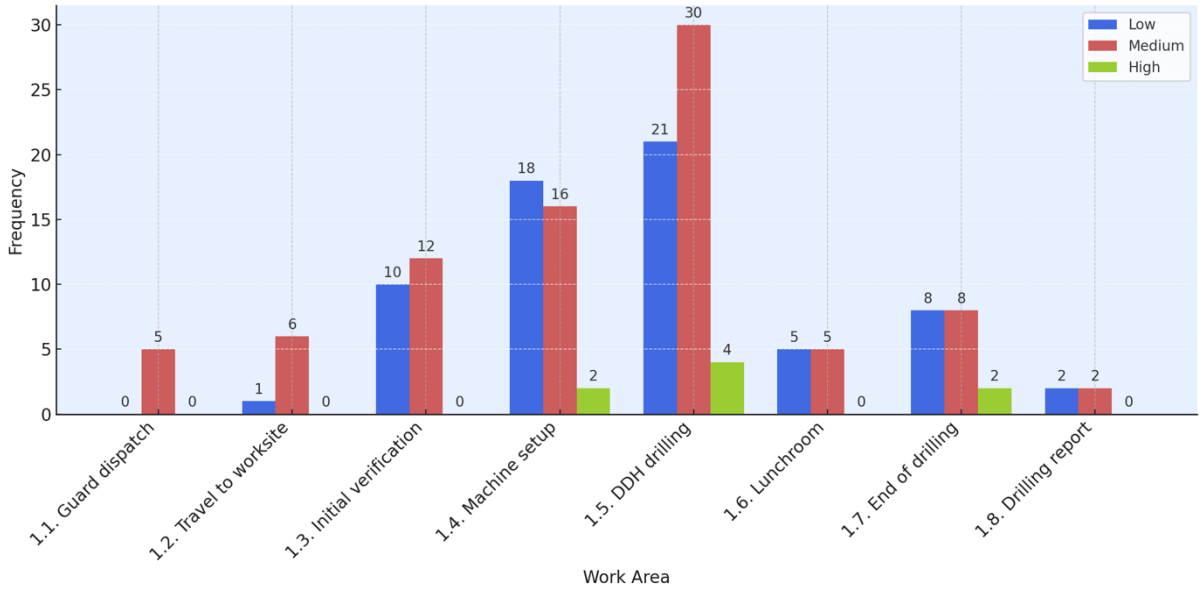
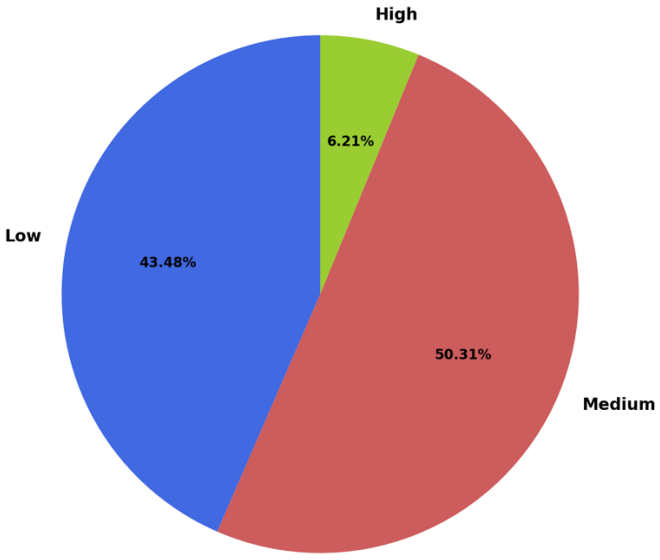


Graph No. 1: Risk assessment of diamond drilling activity

Source: Table 16.

Comment:

It can be seen in the figure that we have in all cases risks from Low to High, the largest number of risks are on DDH Drilling which are 55, of which the medium risks are the majority: 30 risks, then it is on the conditioning of the machine with 36 risks, of which most are Low: 18, but the means are 16, followed by those of Initial verification of work which are Low: 12 and Medium are 10.



Graph No. 2*:* Consolidated level of risk of activities

Source: Table 16.

Comment:

Figure 2 shows that the medium risk level is the highest percentage: 56%, followed by low risk 38% and high risk with 6%.

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According to the research, the activities of the tasks carried out in underground diamond drilling are considered using four types of drilling machines (Drillcat, H 400-2, LM75, LM90) taking the sample of the workers who perform this activity in the Parcoy Mining Unit – Consorcio Minero Horizonte.

Information on the machines used in underground diamond drilling

The product of the review of the information in the manufacturer's manuals of diamond drilling machines (LM75, LM90, Drillcat, H400-2) is made an a priori comparison of the characteristics of the machinery used in underground diamond drilling.

Tables have been made to establish the control of critical risk, identifying them for aspects such as: Transport of personnel and circulation of light vehicles, Transport of electricity, Transport of hazardous materials and waste, Risk in the stability of the rock mass,

This allows us to appreciate when the risks reach the level or consideration of being critical in the case of transport of hazardous materials and waste, in which they are established by aspects or criteria safeguarding the integrity of people, equipment and above all the integrity of the waste to prevent its dissemination that could significantly affect the environment or context.

In the same way, the critical risk of ventilation has been seen given the concentrations of toxic gases, combustion and measures to detect them and respond in a timely manner have been established in the analysis, likewise in the management of critical risks in the Consorcio Minero Horizonte – Parcoy Unit a scope of essential risks from the period 2020-2022 was carried out, having the data of accidents and the way in which preventive controls were implemented.

Table 4: Occurrences of accidents in CMH - Parcoy

Goings-on	2020 Period	Period 2021	Period 2022
Fatal Accidents	1	0	0
Disabling Accidents	4	2	1
Minor Accidents	10	8	6
Total	15	10	7

Source: Master's Degree Course

Perception of risk management

According to the critical risks identified, surveys were carried out on the workers in underground diamond drilling, in order to understand what the risks mean and their results are presented below.

Table 5: Diamond Piercing Risk Surveys

Critical risk Answer	Electrical risk	Ventilation risk	Rocky Mass Risk	Transport risk	Hazardous Materials Risk
Yes	31	23	30	29	30
No	3	11	4	5	4
SubTotal	34	34	34	34	34

Source: Questionnaire applied

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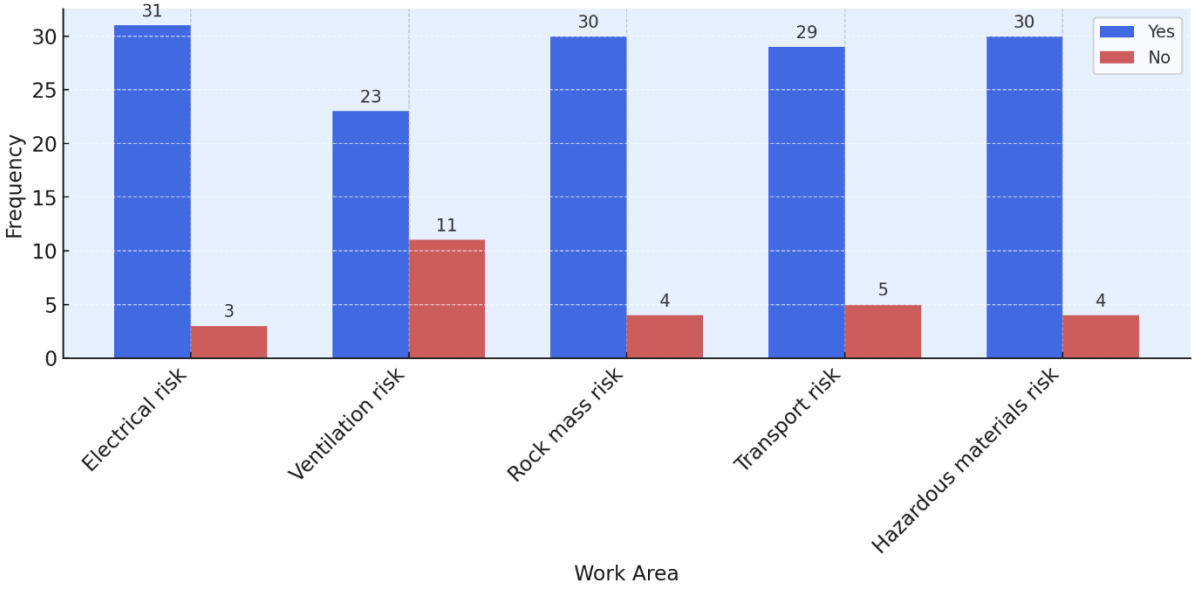

Graph N° 3: Result of the survey on risks perceived by workers in underground diamond drilling

Source: Master's Degree Course

Comment:

It can be seen that the risks have a level of appreciation on the part of the surveyed workers, in such a way that they consider the highest risk, the electrical risk since 31 agree with it, rock mass risk and hazardous materials risk indicate that they are almost as risky, and 29 consider that it is followed by transport and the lowest is the risk of ventilation.

Table 6. Summary of the Job Security Perception Survey

A survey was applied to the 34 workers who responded to 20 items that were favorable, from that criterion the perception of job security is favorable.

Aspect	Yes	No	Condition
Security Awareness	32	2	Favorable
Knowledge about the dangers of drilling	32	2	Favorable
Participation in the election of the Security Committee	23	11	Favorable
Knowledge about those responsible for the company's security	32	2	Favorable
Knowledge of occupational safety standards	32	2	Favorable
Knowledge of diamond drilling safety risks	34	0	Favorable
Existence of implemented standards on occupational safety	32	2	Favorable
Respect for the safety standards established by the company	29	5	Favorable
Security Compliance	30	4	Favorable

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Safety training by supervisors	33	1	Favorable
Knowledge to avoid risks in the workplace	34	0	Favorable
Knowledge of company policies	29	5	Favorable
Compliance to implement an occupational safety system	34	0	Favorable
Proper use of personal protective equipment	27	7	Favorable
Personal protective equipment suitable for the job	29	5	Favorable
Accident prevention standards implemented in the company	29	5	Favorable
Health insurance implemented for workers	34	0	Favorable
Trainings as part of the Security Program	33	1	Favorable
Training in the use of the drilling machine	32	2	Favorable
Knowledge of diamond drilling machine parts	32	2	Favorable
Total	31.1	2.9	

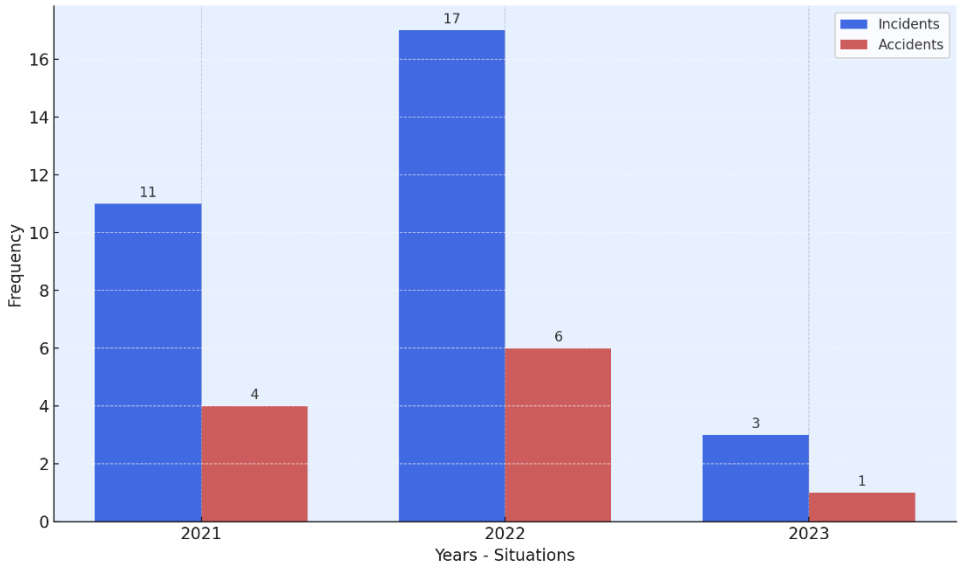
Source: Own elaboration

It can be seen that all aspects are favorable with respect to the perception of safety in the workplace.

Table 7. Comparative report of incidents and accidents

Situations	2021	2022	2023
Incidents	11	17	3
Accidents	4	6	1

Source: Company Registry



Graph N° 4. Comparison of incidents and accidents in the company

Source: Table 7

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DISCUSSION OF RESULTS

Studies such as that of Bodero (2021), which specifies the application of field inspections that was effective in identifying risks, observing a series of risks when working with drilling equipment in mining exploration, proposing a set of measures to mitigate risks, in this regard the study carried out also specified that coincidentally determining that there is a relationship and that the risks mentioned in Bodero are appreciated in this study and the risk in the use of diamond drills was specifically understood, and it is recognized in the IPERC matrix and in the answers raised by the respondents and there are aspects of an electrical and ergonomic nature that must also be observed, indicating the way to avoid risks in the Work Area, all of which in some way corroborates the aforementioned thesis.

Espítia et al (2016) propose a guide that allows controlling risks and making diamond drilling work safe, in which they emphasize the importance of the training that the study has consulted workers and they have agreed to to the fullest extent.

Mujtaba et al (2018) in their article on identification of risk mitigation in drilling activities, in which drilling activities have been considered to be dangerous and/or risky and require identification, reorganization of activities and determination of controls, it can be seen that the study determines that workers are aware of the risks regarding diamond drilling.

Concepción (2022), in his study, understands the need for signage and that it is important for safety and health, since its contribution significantly influenced the prevention, control, protection in underground diamond drilling works, the study also allows us to appreciate these facts, which have been considered important.

Sánchez Chavarría (2020) in his thesis highlights that the use of management tools allows risks to be controlled in diamond drilling work, it is appreciated that these influence the prevention, protection, evaluation and control of risks in diamond drilling work, all this is fully corroborated in all senses, since the use of management tools and the preparation to mitigate or eliminate risks are visualized.

Cabanillas (2021) research on the safety and environmental management plan in diamond drilling highlights the absence of reports of disabling or fatal accidents thanks to a map of prevalent and emergency risks and the application of measures to mitigate environmental impact.

In relation to it, actions have been taken to avoid disabling or fatal accidents, being essential prevention, identification, recognition, compliance, etc., a fact in which most agree.

Rodríguez Arias (2021) in his study for the improvement of Occupational Health and Safety management according to OHSAS 18001 Standards, determining that the instrument applied allows the improvement of occupational health and safety management, as well as this, this study is based on ISO 45001 standards, evolving and improving the very conditions of occupational health and safety.

It should also be noted that it is fully proven that workers in underground diamond drilling are exposed to various hazards and levels of risk.

The characteristics of the machines used in the activity moderately influence the levels of risks of underground diamond drilling.

The identification and analysis of critical hazards by the worker has a positive influence on the reduction of accidents and incidents in underground diamond drilling activity.

Finally, *the identification of risks in underground diamond drilling according to the characteristics of the machines will help to minimize risks in diamond drilling operations*. And the study has categorically proven this

CONCLUSIONS

- The study has determined that the entire process has been organized and considered appropriately, in addition to the fact that the survey of the workers allows us to appreciate that the management is in

appropriate conditions, there is a high knowledge of occupational safety, they are aware of the risks of diamond drilling, moderately they are aware of the need for participation in the safety committee, there is a high level of knowledge of occupational safety standards, knowledge of the safety risks in diamond drilling, all of which corroborate the appropriate characteristics of the GSSO.

- In addition, the value of the risks of diamond drilling activity in underground mining has been identified, with drilling being the highest risk, followed by machine conditioning.
- Risk control has been established in diamond drilling underground mining, according to which the criteria for control can be determined, by means of protocols that have identified the critical risks by sector or segment in such a way that they can be visualized and prevented.
- Protocols have been determined for the control of critical risk, with respect to the transport and transmission of energy, in addition to establishing protocols for the control of critical risk of hazardous materials, safety protocols to consider those inherent to the rock mass, protocols for attention to critical risk to aspects related to ventilation, those that are consolidated with surveys in this regard that recognize that the risk of diamond perforation is moderate, with ventilation being the lowest risk.

RECOMMENDATIONS

- A standard methodology must be regulated to identify hazards and risks to mining activities.
- An investigation should be carried out that analyzes in an exhaustive and detailed way everything related to the use of the SE suggests that an in-depth investigation be carried out in manipulation of drill pipe.

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